

Diversity of termites (Isoptera) on industrial forest plantation of *Eucalyptus pellita* stands of tropical ecosystem in Riau, Indonesia

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Abstract. Prastyaningsih SR, Hardiwinoto S, Musyafa, Koranto CAD. 2020. Diversity of termites (Isoptera) on industrial forest plantation of *Eucalyptus pellita* stands of tropical ecosystem in Riau, Indonesia. *Biodiversitas* 21: 5498-5505. *Eucalyptus pellita* is an alternative tree species for pulp and paper of industrial forest plantation. One of the forest plantation's negative effect is the loss of biodiversity and vulnerable to pest and disease. Termites are one of the pests attacking the forest plantations and play an important role in the ecological process. Need a better understanding of the termite role ecosystem process in *E. pellita* stands. This research aimed to determine the diversity of termite species found in *E. pellita* stands at different rotation and ages of stands. Termite diversity sampled by the transect sampling method in the 4th and 5th rotation with four-level ages (1, 2, 3, 4-years-old). The transect area was divided into 24 plots (100 m x 2 m). The termites in the *Eucalyptus* stand consist of two families (Termitidae and Rhinotermitidae), five subfamilies (Termitinae, Macrotermitinae, Nasutitermitinae, Rhinotermitinae, and Coptotermitinae), and eight species (*Discupiditermes nemorosus*, *Macrotermes gilvus*, *Termes rostratus*, *Amitermes dentatus*, *Microcerotermes* sp., *Nasutitermes matangensis*, *Schedorhinotermes medioobscurus*, and *Coptotermes havilandi*). The diversity index (H) in the 4th rotation was 1.95, while in the 5th rotation was 1.63, with a similarity in the Sorensen Index of 87.71%. The existence of termites is dominated by the wood feeder group. The species richness of the termites at the two rotations increased with the increase of the stand age.. The relative abundance composition of termites in the 5th rotation, is higher than the 4th rotation. Termite occurrence was influenced by necromass, tree biomass, humidity, and temperature.

Keywords: *Eucalyptus pellita*, relative abundance, Riau, termite diversity

INTRODUCTION

Industrial Plantation Forests providing pulpwood and paper raw materials increase continuously every year, from 167.5 million ha in 1990 to 277.9 million ha or 4.06% to 6.95% of the total forest area 2015 (Payn 2015). The most significant increase occurred in East Asia, followed by Europe, North Korea, America, South, and Southeast Asia. Tropical plantation forest is more crucial because it can reduce deforestation, climate change, energy crises, support livelihood needs, and improve infrastructure and economic quality (Cuong et al. 2020). *Eucalyptus* is the main genera which fast-growing, short rotations, and produce pulp. It has been planted as a commercial scale of industrial plantation forest companies in Indonesia, particularly in Sumatra and Kalimantan. The productivity of commercial *E. pellita* in Sumatra is around 16-18 m³/ha/year (Hardwood and Nambiar 2014). *E. pellita* wood has physical and chemical properties in the form of holocellulose content (75%), alpha-cellulose (49%), lignin content (29%), ethanol content (3.08%), and fiber length of 1.02 mm (Lukmandaru et al. 2016) suitable as raw material for pulp and paper industry. *E. pellita* shows the characteristics of well growing and prominent wood characteristic compare to the other two species, namely *E. grandis* and *E. urophylla* (Prasetyo et al. 2017). Investment and expansion in *Eucalyptus* plantations and pulp mills is

predicted to continue sustainably (Phillips 2013).

Eucalyptus pellita is a native species to Australia, Papua New Guinea, and Indonesian Papua. *E. pellita* is an exotic plant that is suitable to be planted in tropical areas with hot temperatures and humid tropical climates such as in Sumatra (Hardwood 1998). Subtropical plantation climate, the rotation in a period of 25-40 years, will encounter problems in a long period. Meanwhile, industrial plantations forest in the tropical area is managed intensively and harvested in the rotation of 5-8 years, a vulnerable site. Sinarmas Forestry Company in Riau forest areas started to plant their clonal forestry with *E. pellita* in 2003, replacing *Acacia mangium* that was attacked by pests and diseases. In sustainable forest products, the area is divided into compartments of the same size, short rotation by the clear-cutting cycle of 5 years, and switch to order rotation. At present, *E. pellita* plantations in the forest areas are in fourth and fifth rotation.

The industrial plantation forest of *E. pelita* is set up in a homogeneous tree, as monoculture ecosystems. In this condition, the stands will be sensitive to organism attacks as pests and diseases, especially termite. Monoculture plantations forest provide an abundant source of food for termite so that the damage or death of valued species leads to the economic problem. When an exotic species is planted in monoculture, stands will also be sensitive toward the termite attack. They can destroy the root system and cause

the death of the seedlings or young plant, or decrease wood produced. In addition, intensification of deep agriculture influences abundance, biomass, and species richness (Jones and Prasetyo 2002; Jones et al. 2003) and decreases in soil feeder, replaced by termite wood feeder (Jones et al. 2003).

In many tropical and subtropical ecosystems worldwide, termites are soil macro-fauna that exist abundantly and play a key role in the decomposition process. Termite activity contributes to the nutrient cycle and improves soil structure and fertility (Jouquet et al. 2011). Termite as an engineer of soil ecosystems, but the activity of several termites as agricultural pests (Govorushko 2019). Termites can attack and spread around trees, causes damage, and death of good trees at any stage of development from young or mature trees, so that they can be a potential pest, especially in monoculture oil palm plantations (Bong et al. 2012; Kon et al. 2012) or industrial forest plantations (Junguiera and Florencio 2018; Morais et al. 2018; Kissi et al. 2019). Termites have caused exotic species damage in the tropical area as a limiting factor in developing commercial *Eucalyptus* forests (Cowie et al. 1989).

The study of termites as a threat to industrial plantations and biological indicators of ecosystems changes is crucial. In the form of an inventory of termite species and their abundance, this research was conducted to determine species diversity at various rotations and stand ages in *E. pellita* industrial plantations

MATERIALS AND METHODS

Study area

This research was conducted in a plantation forest managed by Sinarmas Forestry located in Pelalawan District, Riau Province, Indonesia, namely Sorek and Malako. The climate is wet tropical, type A (Schmidt Ferguson). Mineral red-yellow podsollic soil type with low soil fertility (BPS Statistics Pelalawan District 2017). Before 1990, the location was a mixed lowland Dipterocarpaceae forest, which was subsequently classified into secondary forest. In 1996, Sinarmas Forestry obtained a concession holder in Riau as a plantation forest company that produces wood raw material for the pulp industry with *A. mangium* as the main tree species. From 2003 until now, the company replaced the *A. mangium* with the clonal forestry of *E. pellita*.

Termites were collected from two rotations stands, namely the 4th rotation in Malako site and the 5th rotation in Sorek site (Figure 1) from October to December 2019. For each rotation site, the termite samples were taken at four age levels (1, 2, 3, and 4 years), repeated by three plots in different compartments so that the total samples were 24 plots. In each plot observation, the environmental parameter was measured, such as leaf litter, necromass, biomass of tree, humidity, temperature, and soil pH.

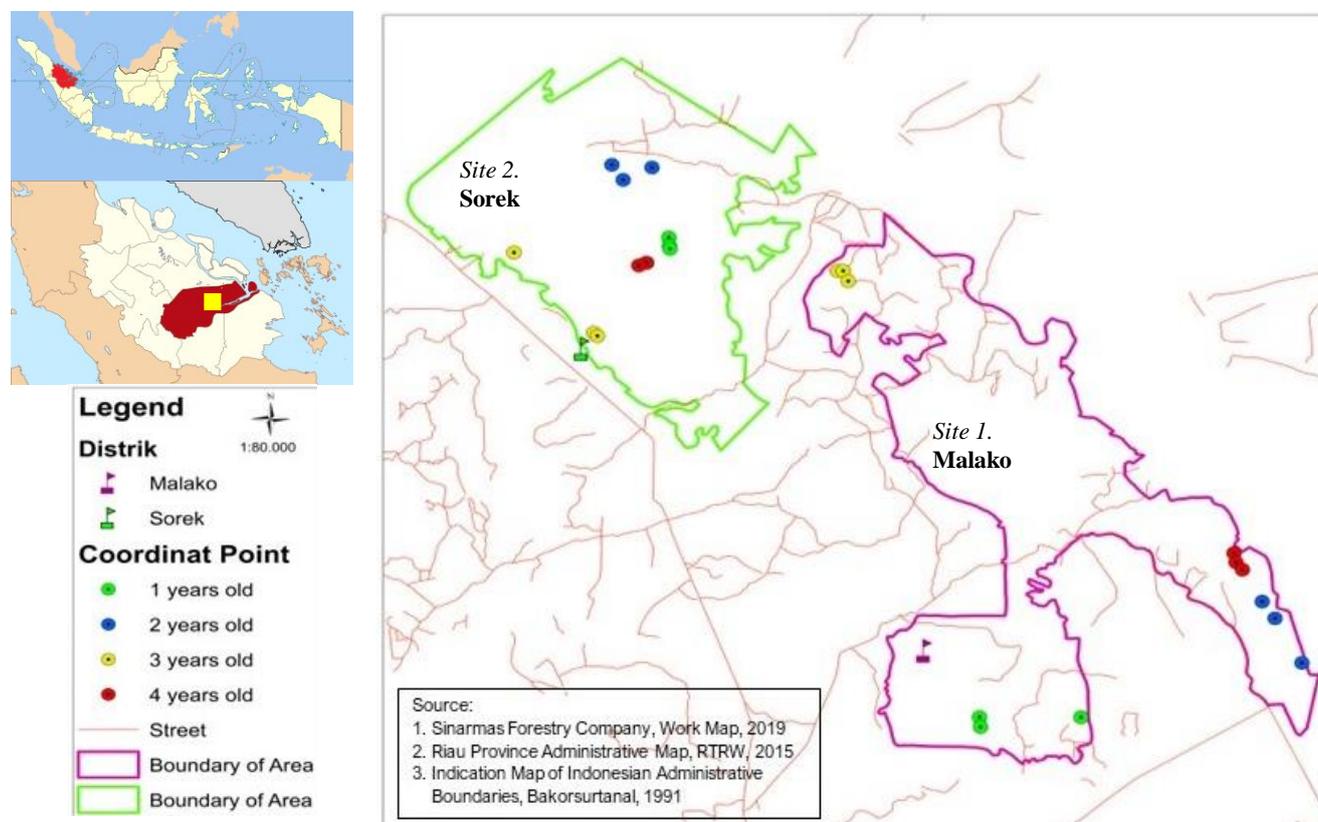


Figure 1. Location of the study sites of *Eucalyptus pellita* stands in Riau, Indonesia (Sinar Mas Forestry Company, 2019). *Site 1.* The 4th rotation of Malako (coordinate point 0° 3' 48.77" N-102° 11' 29.99" W with 20.4-55.6 m). Forest areas consist of lowland, hilly, and partly swamps with slopes varying between 0 and 15%. *Site 2.* The 5th rotation of Sorek (coordinate point 0° 13' 9.75" N-102° 1' 59.47" E, with an altitude of 40.0-63.3 m). The forest area consists of mostly lowland, partly hilly with slopes varying between 0 and 40%

Termite sampling

Sampling of termite, soil, litter, nest, and wood

The transect protocol provides a measure of the relative abundance of termite based on the number of counters with each species in transect by Jones and Eggleton (2000) (Figure 2). The standard sampling protocol is based on 100 m transects with a width of 2 m, divided into five sections. Each section was divided by a centerline into 20 subsections namely the right and the left subsection. Searching and sampling were carried out by two people for 30 minutes. Then 30 minutes, later samplings were taken on microsities, namely necromass, litter, and roots. Free searching was made on wood stumps as necromass, litter, and roots for 15 minutes within a radius of 200 meters. Termites were collected using a brush dipped in alcohol 70%. The soldiers were separated in 70% alcohol in a 20 ml glass bottle (Pardeshi et al. 2010), and they were identified.

Identification of termite species

Soldier castle is used for morphological identification to species level. The identification starts with observing the size of the termite's head, fontanelle, labrum, pronotum, mandibles shape, and antennae number. The measurement of the soldier head is the length from the head to the base of the mandible and the width of the head in millimeters. Termites were placed in petridish with 70% alcohol. All parts of the termite body are observed and measured by a microscope camera and optilab software under the Olympus SZ61 stereo microscope. The results of observations and measurements compared with the key determination by Tho (1992). After being identified, termite species are classified in one functional feeding and nesting group based on Bong et al. (2012) and Donovan et al. (2001).

Data analysis

The data analysis used were species richness (S), relative abundance (K), index of species diversity (H'), and similarity index (SI). The abundance of termites was assessed based on the number of termite species encounters

at each plot to provide a relative frequency of the presence. Jones et al. (2003) defined the term encounter as recorded presence of a species in one section and did not measure the absolute abundance per unit area. The Shannon and Wiener function were used to calculate the species diversity with the following formula:

$$H' = \sum_{i=1}^n p_i \ln p_i$$

H' : Index of species diversity

p_i : Proportion of the total sample belonging to i^{th} species

Assemblage similarity between two habitats (the fourth and the fifth rotations) was estimated by Sorensen's index.

$$QS = \frac{2C}{A+B} \times 100\%$$

QS : Sorensen's similarity coefficient

A : number of species in sample A

B : number of species in sample B

C : the same of number species in sample A and sample B

Logistic regression was used to determine relation between environmental variables (leaf litter, necromass, biomass of tree, humidity, temperature, and pH) and termite occurrence (Keng and Rahman 2012).

RESULTS AND DISCUSSION

A total of eight species (*Discupiditermes nemorosus*, *Macrotermes gilvus*, *Termes rostratus*, *Amitermes dentatus*, *Microcerotermes* sp., *Nasutitermes matangensis*, *Schedorhinotermes medioobscurus*, and *Coptotermes havilandi*) belonging to five subfamily (Termitinae, Macrotermitinae, Nasutitermitinae, Rhinotermitinae, and Coptotermitinae), and two families (Termitidae and Rhinotermitidae) were identified in the *E. pellita* stands (Table 1).

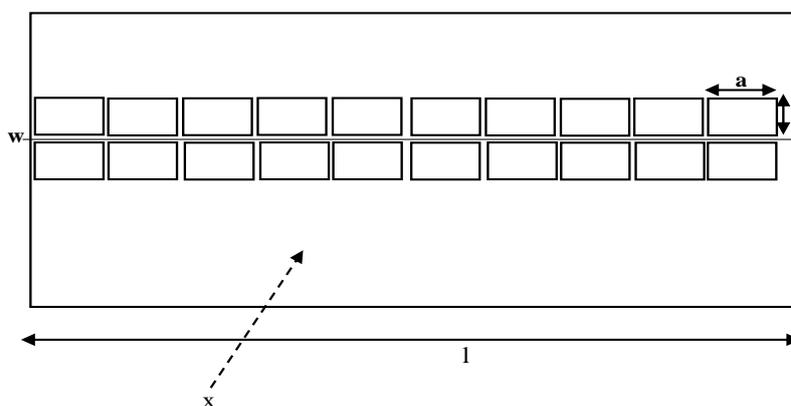


Figure 2. Sampling of termite. Note: x (l length =100 m, w width= 20 m); transect (a length=5 m, b width=2m)

Table 1. List of termite species collected from industrial forest plantation in *Eucalyptus pellita*

Sampling location	Age	Family	Subfamily	Species	Feeding group*	Nesting group
4th rotation of Malako	1 year old	Termitidae	Termitinae	<i>Discupiditermes nemorosus</i>	Soil feeder (III)	Epigeal, mound
	2 years old	Termitidae	Termitinae	<i>Discupiditermes nemorosus</i>	Soil feeder (III)	Epigeal, mound
		Termitidae	Termitinae	<i>Termes rostatus</i>	Soil-wood interface (III)	Epigeal, wood
	3 years old	Termitidae	Termitinae	<i>Microcerotermes</i> sp.	Wood feeder (II)	Wood
		Termitidae	Termitinae	<i>Discupiditermes nemorosus</i>	Soil feeder (III)	Epigeal, mound
		Termitidae	Termitinae	<i>Termes rostatus</i>	Soil-wood interface (III)	Epigeal, wood
		Termitidae	Macrotermitinae	<i>Macrotermes gilvus</i>	Wood-litter interface (II)	Epigeal, mound
	4 years old	Termitidae	Termitinae	<i>Microcerotermes</i> sp.	Wood feeder (II)	Wood
		Termitidae	Nasutitermitinae	<i>Nasutitermes matangensis</i>	Wood feeder (II)	Arboreal
		Termitidae	Termitinae	<i>Discupiditermes nemorosus</i>	Soil feeder (III)	Epigeal, mound
		Termitidae	Termitinae	<i>Termes rostatus</i>	Soil-wood interface (III)	Epigeal, wood
		Termitidae	Macrotermitinae	<i>Macrotermes gilvus</i>	Wood-litter interface (II)	Epigeal, mound
		Rhinotermitidae	Rhinotermitinae	<i>Schedorhinotermes medioobscurus</i>	Rotten wood (I)	Wood
		Termitidae	Termitinae	<i>Amitermes dentatus</i>	Soil-wood interface (III)	Inquilines
	Termitidae	Termitinae	<i>Microcerotermes</i> sp.	Wood feeder (II)	Wood	
	Termitidae	Nasutitermitinae	<i>Nasutitermes matangensis</i>	Wood feeder (II)	Arboreal	
	Rhinotermitidae	Coptotermitinae	<i>Coptotermes havilandi</i>	Fresh wood (I)	Wood	
Diversity of Shannon				1.95		
5th rotation of Sorek	1 year old	Termitidae	Macrotermitinae	<i>Macrotermes gilvus</i>	Wood-litter interface (II)	Epigeal, mound
	2 years old	Termitidae	Termitinae	<i>Discupiditermes nemorosus</i>	Soil feeder (III)	Epigeal, mound
		Termitidae	Macrotermitinae	<i>Macrotermes gilvus</i>	Wood-litter interface (II)	Epigeal, mound
	3 years old	Termitidae	Termitinae	<i>Microcerotermes</i> sp.	Wood feeder (II)	Wood
		Termitidae	Termitinae	<i>Discupiditermes nemorosus</i>	Soil feeder (III)	Epigeal, mound
		Termitidae	Termitinae	<i>Microcerotermes</i> sp.	Wood feeder (II)	Wood
	4 years old	Termitidae	Nasutitermitinae	<i>Nasutitermes matangensis</i>	Wood feeder (II)	Arboreal
		Termitidae	Termitinae	<i>Discupiditermes nemorosus</i>	Soil feeder (III)	Epigeal, mound
		Rhinotermitidae	Rhinotermitinae	<i>Schedorhinotermes medioobscurus</i>	Rotten wood (I)	Wood
		Termitidae	Termitinae	<i>Microcerotermes</i> sp.	Wood feeder (III)	Wood
		Termitidae	Nasutitermitinae	<i>Nasutitermes matangensis</i>	Wood feeder (III)	Arboreal
	Rhinotermitidae	Coptotermitinae	<i>Coptotermes havilandi</i>	Fresh wood (I)	Wood	
	Diversity of Shannon				1.63	
Index Similarity				87.71%		

Note: * Feeding Group by Bong 2012 and Donovan et al. 2001

Family Termitidae was the mayor of groups found in *E. pellita* stands. The result in accord with the statement of Cheng et al. (2008) and Subekti et al. (2012) that termites on mineral soils are dominated by the Termitidae. The diversity of termite in *E. pellita* is relatively low. This finding is similar with Alamu et al. (2018), who found eight species of termites in *Eucalyptus* plantations in Nigeria. This result is associated with monoculture. Other monoculture plantations such as oil palm and rubber are also reported to have low species diversity. A study on termite diversity in Jambi tropical forests showed that species richness in monoculture was lower than nature forest (Jones et al. 2003). Aiman et al. (2014) proved that the termite species richness and abundance in monocultures (21 species) were less than natural forests (32 species). Keng and Rahman (2012) noted 29 species of termites in natural forest areas, and nine species in oil palm plantations. Bong et al. (2012) recorded six species, while Kon et al. (2012) found 18 species of termites on oil palm plantations in Malaysia. Kissi et al. 2019 recorded 12

species of termites in rubber plantations of Africa, while Hidayat et al. 2018 found six species in Melawi, West Kalimantan Indonesia on rubber plantation.

Eucalyptus pellita plantations of Sorek and Malako have different rotation or time period for establishing the stands. Sorek is the site that first planted *E. pellita*, while Malako planted five years later or one rotation thereafter. At present, Sorek enters the 5th rotation while Malako enters the 4th rotation. This rotational difference becomes important when it comes to monoculture plants. The diversity index at the 5th rotation is lower ($H' = 1.63$) than the 4th rotation ($H' = 1.95$). Species equality index = 87.7% means that the two locations are relatively homogeneous. The species of termites are similar because both locations are near. The remaining 12.3% of termites in the 4th rotation was not found in the 5th rotation. The diversity of termites in tropical forests is significantly affected by various disturbances (Eggleton et al. 1996; Jones et al. 2003). Reduced canopy cover and micro-climate change have caused termites to lose their food and habitat. The

longer duration of intensive monoculture plantation of *E. pellita* has affected the diversity of termites in the study sites.

The number of species in both sites increased as stand age increased (Figure 3). Industrial plantations consist of logging and regeneration with the same area every year during the cutting or rotation cycle. The method of harvesting is clear-cutting. All trees are logged down, and the ground surface becomes open. Temperature and humidity are some of the microclimates that change due to logging. Direct sunlight penetrates the soil surface so that termites cannot develop properly. Tree loss will reduce the diversity and abundance of termites (Davies et al. 2003). The practice of clear-cutting will impact micro-habitats resulting in the loss or drastic reduction in the diversity and composition of termite species. When *E. pellita* stands are less than one year old, the canopy does not close completely, so the temperature and humidity fluctuations are quite high. Canopies among the trees have covered each other to increase soil moisture; there will be many *D. nemorosus* mounds. Soil feeders are represented by *D. nemorosus*. Moist soil and canopy cover can protect termites and microclimate soils (Jamil et al. 2017). Canopy cover was positively correlated with diversity and termite abundance (Felicitas et al. 2018). As the age of the holder increases, the diversity of termite soils increases. The colonization of termite species can adapt to a homogeneous environment and gradual changes in microclimate conditions towards a stable environment for soil termite development (Kon et al. 2012).

The relative abundance of termites in the 4th rotation was dominated by *D. nemorosus* (25%), followed by *T. rostatatus* (18%), *Microcerotermes* sp. (14%), *N. matangensis* (14%), *M. gilvus* (11%), whereas in the 5th rotation was dominated by *Microcerotermes* sp. (36%), followed by *D. nemorosus* (20%), *N. matangensis*, (14%) and *M. gilvus* (14%) (Figure 4). The relative abundance of individuals in the 4th rotation was dominated by *D. nemorosus*, while *Microcerotermes* sp. and *D. nemorosus* dominated the 5th rotation belongs to a group of soil

termites founds at both locations and age levels, builds epigeal nests or mounds in soils or near canals, containing high organic matter such as humus. *Microcerotermes* sp. has a higher relative abundance in the 5th rotation. This species was found in several places in the sites such as necromass, stumps, even on living trees. *T. rostatatus* and *A. dentatus* were only found at the 4th rotation, under the log stump left from previous logging activity. *A. dentatus* is a species of inquiline found in the *T. rostatatus* nest. These stumps provide suitable microhabitats for termites. *T. rostatatus* is soil-wood interface feeders eating organic matter and lives under log stumps (Eggleton 1997). The absence of *T. rostatatus* and *A. dentatus* in the 5th rotation is thought to be due to changes in feed sources and environmental conditions.

In tropical forests, termites are very important to soil fauna and contribute to the decomposition of litter and deadwood on the forest floor. After harvesting activities in the previous rotation, the remaining logged tree materials in branches, twigs, or leaves have accumulated in several locations in a very large amount. The amount of litter and biomass of deadwood on the forest floor affects the abundance of termites (Yamada et al. 2003). *M. gilvus* was found in stands aged of 1 and 2 years at the 5th rotation. At the 4th rotation, *M. gilvus* found in plots aged 3 and 4 years. *M. gilvus* was found in weathered wood, make nests in the wood. As reported by Bignell et al. 2010, termite prefers weathered wood, and it will become the preferred food source for termites.

Microcerotermes sp. has the largest proportion in the 5th rotation, observed in the sites such as necromass, stumps even on living trees. This observation is consistent with the research of Miranda et al. (2004) that termite abundance correlated with necromass. Keng and Rahman (2012), Calderon et al. (2018), and Morais et al. (2018) reported that the incidence of termites related to trees, including dead trees, deadwood, and floor litter. The abundance of termites in the *Eucalyptus* plantations in Thailand is influenced by the amount of deadwood on the forest floor (Yamada et al. 2003).

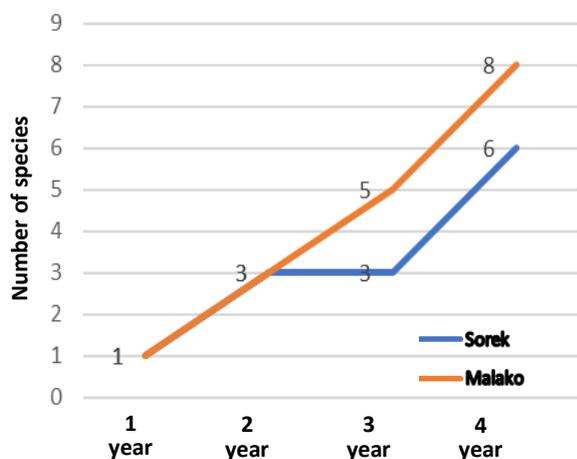


Figure 3. Number of species in industrial forest plantation with *Eucalyptus pellita* based on site and level age

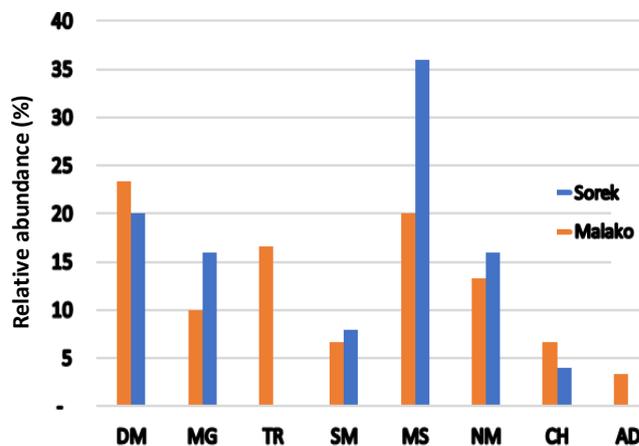


Figure 4. Relative abundance in industrial forest plantation with *Eucalyptus pellita* based on site and species. Note: DN: *D. nemorosus*, MG: *M. gilvus*, TR: *T. rostatatus*, AD: *A. dentatus*, MS: *Microcerotermes* sp., CH: *C. havilandi*, SM: *S. medioobscurus*

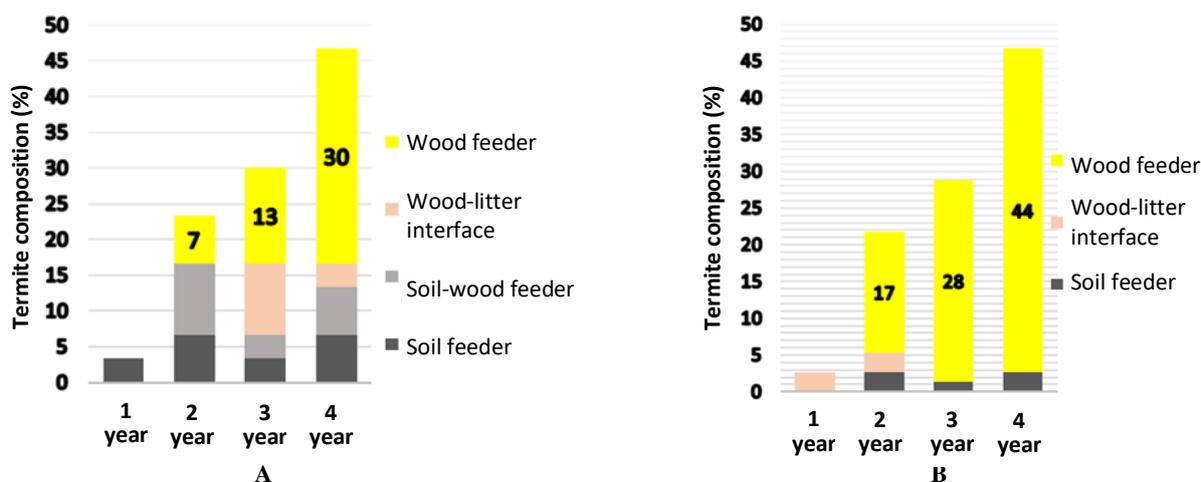


Figure 5. Composition of termite based on feeding group in Malako (A) and Sorek (B) in *Eucalyptus pellita* plantation

Table 2. The coefficient of logistic regression model for termite occurrence with environmental variables

Variables	Coefficient	Exponent (odds)	Standard error	P-value	Significance
Leaf litter	0.002	1.002	0.005	0.694	NS
Necromass	0.242	1.274	0.098	0.014	*
Biomass of tree	0.241	1.272	0.072	0.001	*
Humidity	0.417	1.517	0.180	0.021	*
Temperature	1.303	3.681	0.446	0.003	*
pH	1.704	5.496	2.270	0.453	NS
Intercept	-87.753	0.000	35.159	0.013	*

Note: *: Regression is significant at $p < 0.005$ and NS: Not significant

The main factor controlling termite populations is the availability of standing trees, both live and dead trees (Calderon et al. 2018). *Microcerotermes* sp. has caused damage and death to several *E. pellita* trees. *Microcerotermes* sp. attacks spread in one group (colony) allegedly due to high organic matter content such as the number of stumps and weathered wood. When the environment variables support termite’s life, termites will attack the stands. The tendency of termites spread from one tree to another around it. Thus, termite workers have a role in foraging.

The abundance of *N. matangensis* is found in compartments with high slope, near canals, high humidity, and close canopy confluence. The attack was seen on a field with more nests in trees. Arboreal nests, on stems, lower parts, and branches that grow and form lumps as the population grows, *N. matangensis* can attack and kill trees (Asmaliyah et al. 2012). The species members of Nasutitermitinae are also pests causing damage to tropical plantations (Krishna et al. 2013).

Based on the feeding and nesting group by Bong et al. (2012) and Donovan et al. (2001), we classified the species of termites into four categories, i.e., wood feeders (W), wood litter feeders (WL), soil wood interface feeders (SW), and soil feeders (S). The five wood feeder species (W)

consisted of *Microcerotermes* sp., *N. matangensis*, *C. havilandi* (fresh wood feeder), *S. medioobscurus* (rotten wood feeder), and *M. gilvus* (wood litter). *T. rostratus* and *A. dentatus* are a soil wood (SW) interface, while *D. nemorosus* is a ground feeder (S). The recorded termite species have different nest types, they are wood nest (*C. havilandi*, *S. medioobscurus*, and *Microcerotermes* sp.), arboreal nest (*N. matangensis*), epigeal nest (*D. nemorosus*), inquilines nest (*Amitermes* sp.), and epigeal or wooden nests (*T. rostratus*). The 5th rotation has a higher relative abundance of wood feeders than the 4th rotation (Figure 5).

The presence of wood feeder groups is dominated by *Microcerotermes* sp. Termites are wood feeder insects (*Xylophagus*) or materials that contain cellulose. The older the tree, the cellulose level increases (Sutiyasa 2002). At the age of 1 year, cellulose levels are very significantly different from the age of 2 years and tend to be stable from the age of 2 to 4 years (Akbar et al. 2019). Conversion of forests to *Eucalyptus* plantations in Brazil results in a lower proportion of soil feeders than litter feeders and wood feeders. This is caused by changes in microclimate, habitat, food quality, and diversity (Calderon et al. 2007). Wood feeders are also resistant to habitat conversion than soil feeders (Jones et al. 2003). Correlation between the

presence of termites and environmental factors indicates that termites have a significant relation with necromass, the biomass of tree, humidity, and temperature (Table 2).

In conclusion, the increase in rotation and age of *E. pellita* plantation affected the diversity of termite and abundance. The 4th rotation ($H = 1.95$) had a higher termite diversity than the 5th rotation ($H = 1.63$). The older ages of *E. pellita* stands, then the species number of termites will increase. The number of species increased as following stand ages at 4th rotation is one year (1 species), two years (3 species), three years (5 species), and four years (8 species), while 5th rotation are 1 year (1 species), 2 years (3 species), 3 years (3 species) and 4 years (6 species). The 5th rotation has a relative abundance of wood-feeder termites higher than the 4th rotation. The relative abundance of wood feeder termites increases as an increase in stand age. The occurrence of termites in *E. pellita* plantation was affected by such environmental factors as necromass, tree biomass, humidity, and temperature.

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